

Formation of Marine Biological Thin Layers: Recruitment of Zooplankton

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LONG-TERM GOALS

Our long-term goal is to understand bioluminescent plankton spatial and temporal distributions, and how these affect plankton sensory interactions. Current interest is in how these interactions might be involved in “thin layers”, in marine snow, and in formation of blooms in the ocean.

OBJECTIVES

The first objective, started in June 1998, was to measure bioluminescence in association with thin layers, since this has never been attempted. This required: 1) measuring the vertical distribution of excitable bioluminescence across thin layers in East Sound, WA; and 2) determining the plankton species responsible for bioluminescence in the vicinity of these thin layers.

With the successful completion of the 1998 field season, we had a further focus for 1999. Our objective was to determine the spatial distribution of bioluminescence in the Santa Barbara Channel area from offshore to onshore using a high-resolution sampling strategy, such as that used successfully in the thin layers study. The plankton composition in our study area changes drastically with decreasing water depth, so we also wanted to explore the associations of bioluminescence with marine snow concentration, and zooplankton and phytoplankton distribution in this richly productive marine ecosystem.

Another objective developed this year was to produce a spatially high-resolution map of bioluminescence, the highest in existence as of now. This was done using our new small bathphotometer on a REMUS AUV at the LEO-15 study site in July 1999 to further investigate patchiness of bioluminescence.

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APPROACH

The 1998 Thin Layer study involved multi-disciplinary collaborations, and thus bioluminescence profiles were compared with a suite of other parameters such as marine snow concentrations, zooplankton distributions, fluorescence, and hydrographic measurements. A new profiling bathyphotometer (Case, Herren, Haddock UCSB) measured total stimutable bioluminescence through 21 m depth from a moored station aboard the *RV Henderson*. An independent estimate of plankton numbers was obtained on the same profiling package with an 8-frequency TAPS (TRACOR acoustic profiling system, Dr. D. V. Holliday, TRACOR Aerospace, Inc.) Concurrent measurements of marine snow concentrations were taken with a profiling *in situ* still-camera package (Alldredge, UCSB, MacIntyre *et al.* 1995). To quantify the intensity of potential bioluminescence incorporated within marine snow versus surrounding water, we also collected individual marine snow aggregates and samples of surrounding water (Haddock 1997).

In the Santa Barbara Channel study (early July 1999) we collaborated with D. V. Holliday, who supplied the 6-frequency TAPS for this cruise. Graduate student Christy Herren was trained to operate the TAPS instrument after a training session with C. Greenlaw at Tracor in May 1999. An instrument cage with the new bathyphotometer, the *in situ* still-camera, the TAPS instrument, and a Seabird CTD with a fluorometer were profiled at night at four different stations from offshore to onshore near Santa Barbara, CA in July 1999. A zooplankton tow was collected at each station. An image-intensified camera viewing a 60- cm diameter, 3-mm mesh screen filmed the flash kinetics of bioluminescent plankton (Widder *et al.* 1989) as it profiled at each station.

At the LEO-15 study site in July 1999, the new small bathyphotometer, integrated with a REMUS AUV (C. Von Alt, Woods Hole Oceanographic Institute), was tested for the first time at night in the field (Figure 1). Bioluminescent intensity, fluorescence, backscatter intensity, and water flow through the bathyphotometer were recorded and analyzed over the sampling grid (150-m by 300-m rectangle). Another bathyphotometer, identical to the one on the REMUS, was profiled during the same time period on the O. Scofield optical instrument cage.

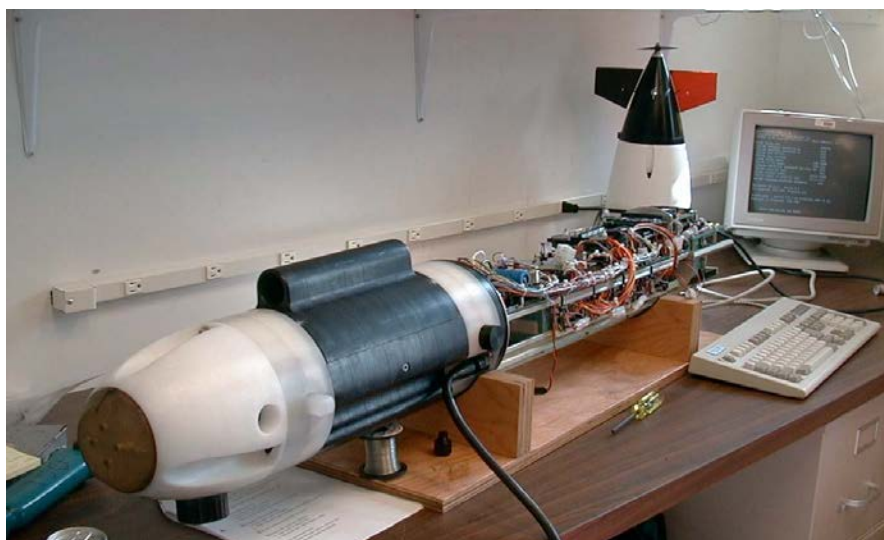


Figure 1: Bathyphotometer integrated with a REMUS AUV.

WORK COMPLETED

We are in the analysis stage for our first objective, bioluminescence associated with thin layers in East Sound, WA. . One of the two 24-hour intensive studies has been examined in detail, and further analysis is continuing. Identification of organisms present in marine snow samples from East Sound, WA, has been completed.

C. Herren gave an oral presentation at the 1999 ASLO conference in Santa Fe, NM, for the Thin Layers special session, and also participated in the ONR-sponsored Thin Layers Conference at the University of Rhode Island May 17-21, 1999.

We successfully completed our cruise in July 1999 in the Santa Barbara Channel. The bathyphotometer was outfitted with an autonomous data recorder for quicker shipboard deployment. Data analysis will begin this year. We are currently applying with other UCSB researchers for shiptime to repeat this study in Dec 2000.

The REMUS AUV test and sampling plan were a success at the LEO-15 study site on July 22, 1999. Collaborations with Oscar Scofield (Rutgers Univ.) and Mark Moline (California Polytechnical State Univ.) are underway to analyze this data. We have begun preparations to place another bathyphotometer on an optical mooring at LEO-15 next summer 2000.

RESULTS

Bioluminescence profiles from an intensive 24-hr experiments at the East Sound, WA, thin layers study site have been examined (Figure 2) and compared with fluorescence profiles. During the day, bioluminescence peaks coincided with fluorescence peaks, but with the onset of darkness thicker layers of bioluminescent organisms were observed that did not coincide with the fluorescence profiles. A double-layer system was tracked throughout the night as seen in the profiles. This clearly demonstrates that while there is patchiness in bioluminescent distribution, there are also persistent structures as well. Plankton samples from these time periods reveal that the dominant member of the bioluminescent plankton during this time were heterotrophic dinoflagellates.

Three-dimensional high resolution maps of bioluminescence, fluorescence, and backscatter at the LEO-15 site were constructed using data collected from the REMUS carrying the bathyphotometer. We are currently collaborating with Mark Moline (Cal Poly Institute) to determine a sampling pattern that would most accurately and efficiently sample the whole flight area in future field studies. We plan to repeat this study with the REMUS next summer for further testing of the bathyphotometer.

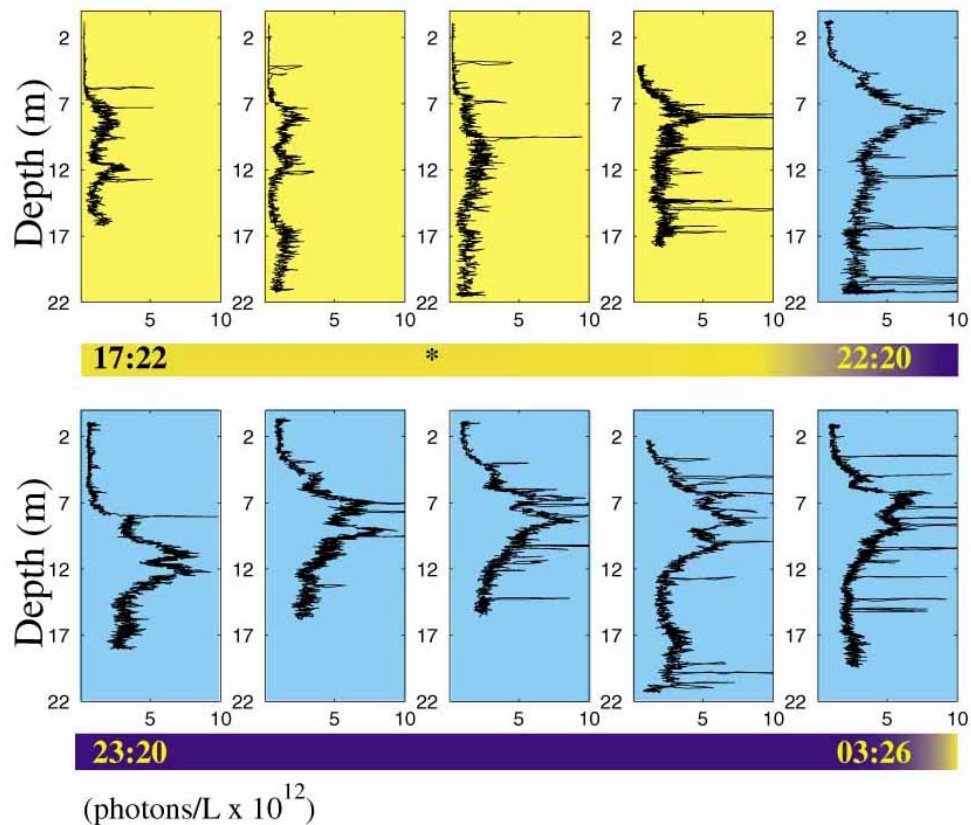


Figure 2: Hourly time series of bioluminescent intensity (photons/sec) over 22 m from evening to dawn in East Sound, WA, June 20-21, 1999. The increase in luminescence recorded at 22:20 was expected, and is due to the dominant bioluminescent organisms in this area, which are photoinhibited heterotrophic dinoflagellates responding to darkness. The large spikes are not layers but are cnidarian zooplankton, known because of their high- intensity, short- residence time in the bathyphotometer.

IMPACT/APPLICATIONS

By using higher-resolution sampling, we view more fine structure in the environment. The new small bathyphotometer has successfully been developed for several sampling modes, and has been deployed in three different marine environments, specifically to perform high-resolution sampling in coastal waters. This has made it possible to test for thin layers, to be integrated with the REMUS AUV, and to be placed on profiling cages with other instruments, that might have been disturbed by past bathyphotometers. with high intake rates (6 l/ sec HIDEX versus 350 ml/ sec for the present instrument).

TRANSITIONS

Plans are underway to build a second REMUS with a bathyphotometer (J. Case and M. Moline) for use in optics studies along the southern Californian coast.

An identical bathyphotometer to the two mentioned previously will be placed on the LEO-15 optical node for high-resolution vertical profiling during June and July 2000 in order to document effects of upwelling events on bioluminescent populations.

Our profiling bathyphotometer is proposed to be used in a study of the Santa Barbara Channel cyclonic gyre in 2000. We hypothesize that bioluminescent plankton are concentrated in the center of the gyre because juvenile fish have been shown to have this pattern (Libe Washburn, pers. comm.) when gyre rotational energy extends into the water column as opposed to only being a surface expression.

RELATED PROJECTS

1 - James F. Case (Santa Barbara) – The bathyphotometer used in this study to measure the bioluminescence potential of the water column was developed under another closely associated grant.

2 – D. Van Holiday (Marconi North America, formerly Tracor) – We are examining correlations between zooplankton distributions measured acoustically by Holiday and distributions of bioluminescence, phytoplankton, and marine snow. Christy Herren was trained on the TAPS-6 operation to use in two field studies in the Santa Barbara Channel this year in conjunction with bioluminescence measurements.

3 - Mark Moline and Oscar Scofield (California Polytechnic State Univ. and Rutgers Univ.) – During the REMUS flights in July 1999 at the LEO-15 site, we collaborated with Oscar Scofield and Mark Moline to obtain preliminary bioluminescence data with concomitant optical data. This will be used to plan data collection from the new optical mooring with a bathphotometer that will take place June 2000.

4 - Edith Widder (Harbor Branch Institute of Oceanography) – Christy Herren will collaborate with Dr. Widder and Dr. Sonke Johnsen to analyze videotapes from the image-intensified camera used in East Sound, Wa, and in the Santa Barbara Channel studies to document bioluminescent organism distribution which will complement bathyphotometer profiles.

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